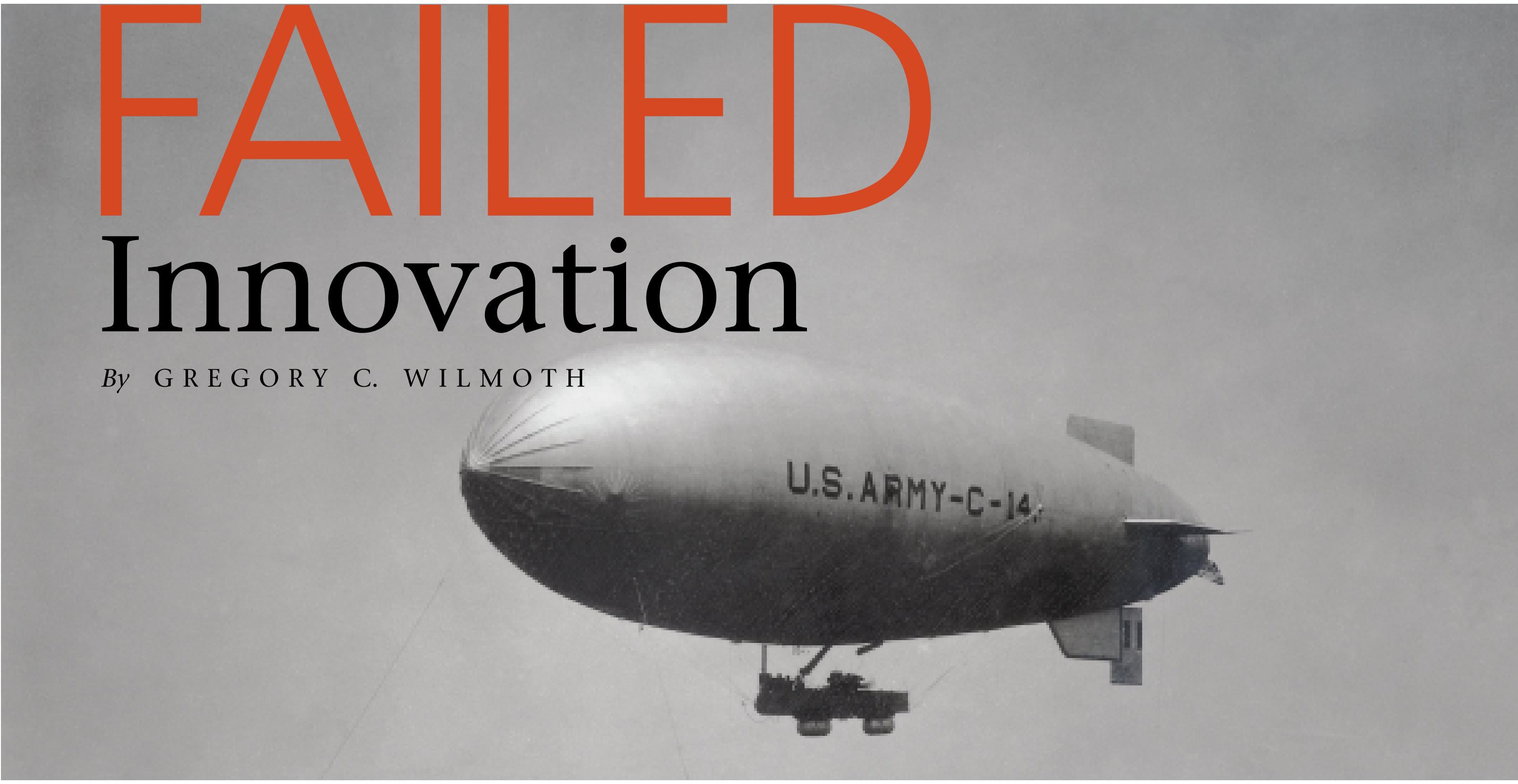
# FALSE-FAILED Innovation

*By* GREGORY C. WILMOTH




U.S. Air Force History Office

**Blimp arriving at Bolling Field.**

History is littered with technologies that failed as innovations. Others, such as gliders and airships, were like desert flowers. They flourished briefly and withered. Then there is the false-failed innovation—a technology that is examined and discarded but that gets a second chance under other conditions and succeeds. Perhaps the best example is inflight refueling, an idea pioneered in the 1920s to extend the range of wood and fabric biplanes. The Army Air Corps set the technique aside in the 1930s as aircraft range and endurance improved. Rediscovered in the late 1940s when the United States tried to build an intercontinental jet bomber, the technology proved invaluable. Air refueling became a capability that quickly spread throughout the services and to other countries.

This article looks at airships, gliders, and air refueling to determine why some promising innovations are permanently discarded while others are profitably resurrected.

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## Lighter than Air

At the turn of the century, rigid airships emerged as a technology in search of a mission. First flown by Count von Zeppelin in 1900, three years before the Wright brothers airplane, lighter than air flight captured public imagination. In Germany zeppelins became a national passion akin to the space race in America during the 1960s.

Many concluded airships might have military uses. H.G. Wells wrote *The War in the Air* in 1907, which featured German *drakenships* that attacked the U.S. Navy and pulverized cities from the sky.

By 1912 airships appeared to be an innovation whose time had come. Germany operated a regularly scheduled airship service. Capable of carrying dozens of passengers as well as hundreds of tons of cargo, they proved more useful than airplanes, fragile toys of the rich which could carry two people for perhaps an hour.

World War I shattered many illusions, including the relative usefulness of airships versus airplanes. In August 1914 both the German army and navy employed lighter than air military craft. Although the army used them for reconnaissance and close air support, by October 1914 only two out of the original inventory of seven remained operational.[1] The navy had limited success with airships used for fleet scouting. Maritime scouts were the result of a strategic blunder. Expecting a close-in blockade by Britain, Germany built few cruisers. When mines and submarines drove the Royal Navy to establish a distant blockade, the German fleet suddenly found that it needed more light cruisers for littoral operations, but none were available. Airships proved to be cheaper and quicker to build than cruisers and served as a substitute for coastal reconnaissance.

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Some visionaries saw another use for airships: strategic bombing. In 1915 Peter Strasser, the head of Germany's naval airship division, got permission from his superiors to mount strategic raids on England. Kaiser Wilhelm II, however, was worried about bombing London and possibly injuring members of the royal family which included his cousin, George V. As a result, air strikes were limited to military installations. Because the technology of the day was not terribly accurate, in a pattern which foreshadowed American bombing of North Vietnam, the list of available targets expanded cautiously, allowing the British time to develop a formidable air defense system.[2]

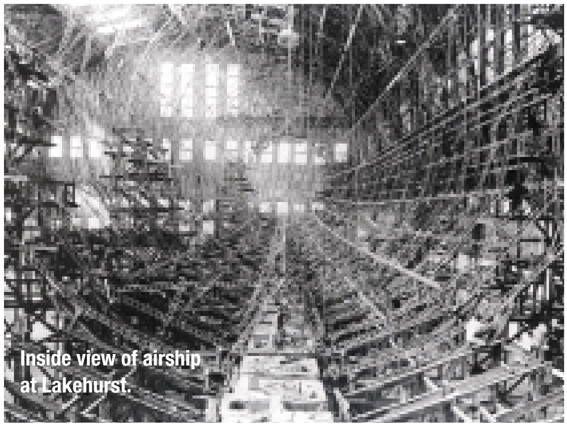
Even when the German army joined the navy bombing campaign its operations remained ineffective. Bombing at night for protection made it hard to navigate and nearly impossible to hit anything with accuracy. As British defenses improved, the only real countermeasure available to airships was to fly at higher altitudes, which further eroded accuracy and navigation. In addition, because German airships used flammable hydrogen as a lift gas they remained highly vulnerable to air defense fires. As losses mounted, the German army withdrew its airships and switched to *Gotha* and later *Giant* bombers in early 1917 while the navy persisted to the end in flying airship raids.


Blimp school, Pensacola.

Naval Historical Center

Moreover, in 1917 the army briefly used a lighter than air craft on a new mission: strategic airlift in support of General von Lettow-Vorbeck, who waged guerilla warfare against British forces that invaded German East Africa. An airship launched from Bulgaria carried food, ammunition, and medical provisions on a one-way mission to resupply the German forces. Although the airship successfully crossed the Mediterranean and Sahara, before Lettow-Vorbeck could be resupplied his forces withdrew into Portuguese East Africa. Near Khartoum in the Sudan the airship was recalled by radio and flew back to Bulgaria. As a result, another potential use for the technology proved to be disappointing and it was soon discarded.[3]

Following World War I the U.S. Navy considered using airships for fleet scouting, in part because of the development of cheap helium in commercial quantities. The reduced lift of helium was thought to be offset by the increased safety of non-flammable gas. The Navy commissioned its first postwar airship from the Zeppelin works and then quickly accelerated the construction of subsequent airships in the United States. As the capabilities advanced naval airmen envisioned another possible mission for lighter than air



Inside view of airship at Lakehurst.

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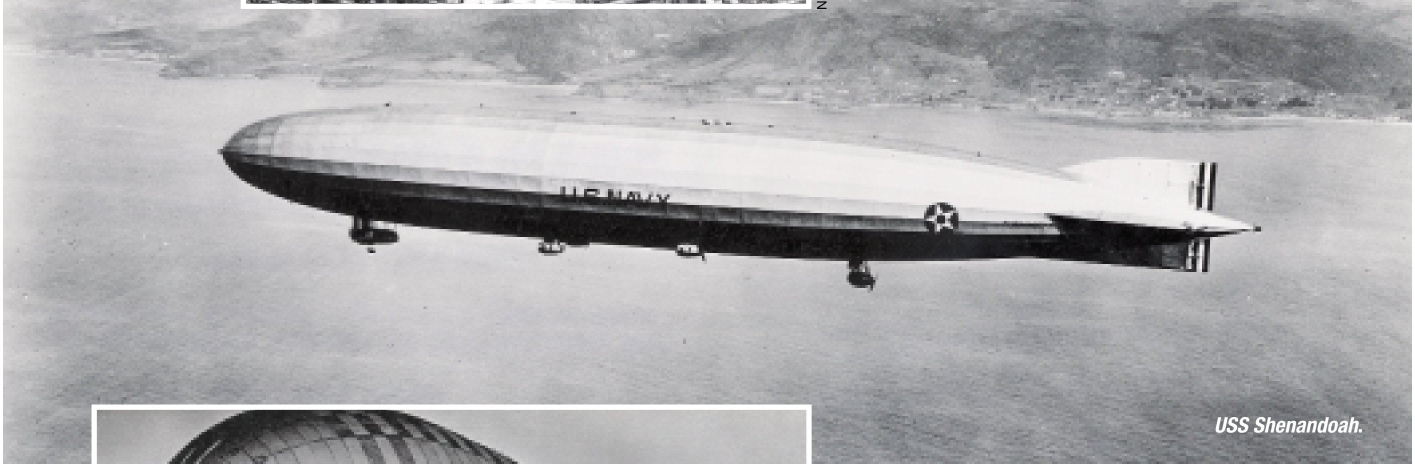

USS Shenandoah.

Naval Historical Center

British dirigible.

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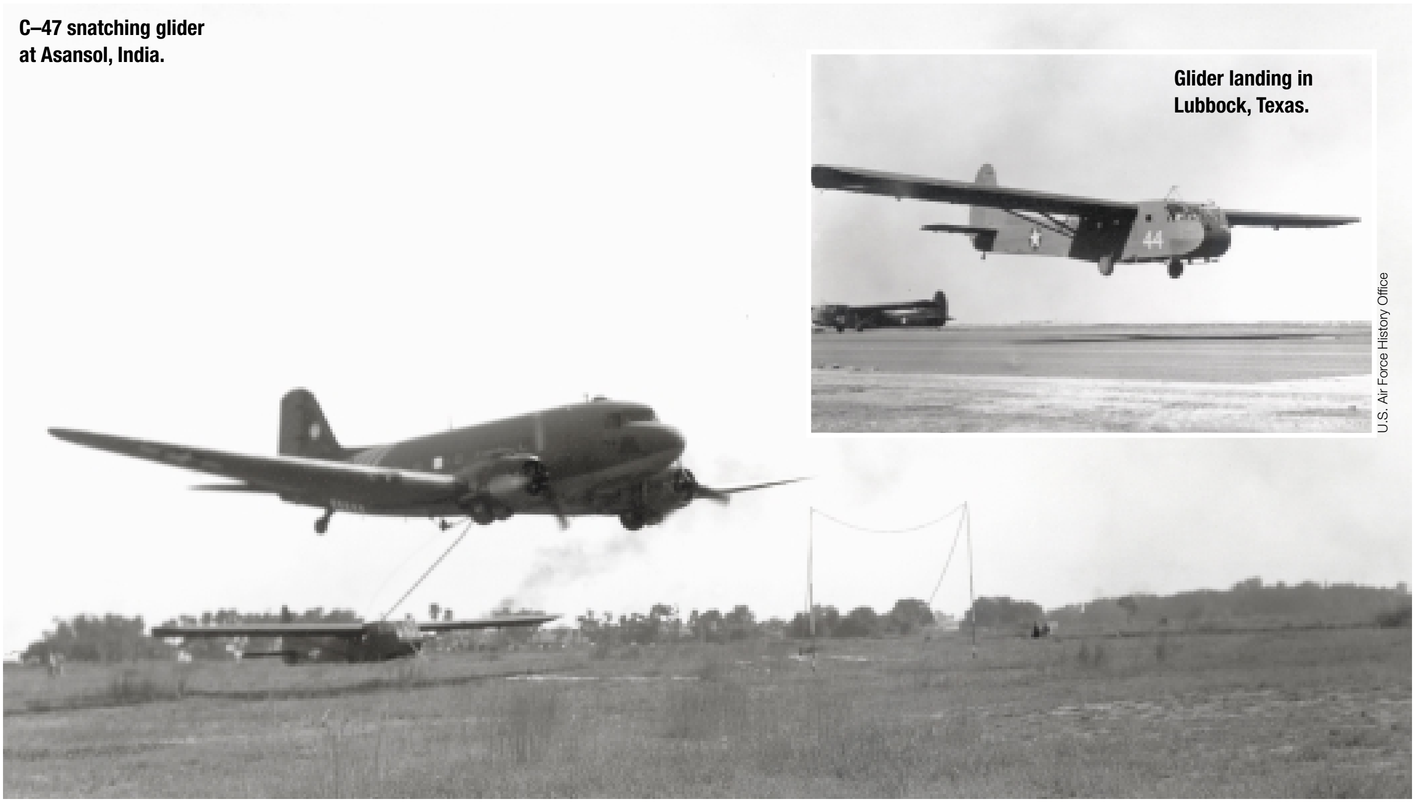
technology, the airborne aircraft carrier. *USS Akron* and *USS Macon* were able to launch and retrieve a small parasite fighter, the F–9C Sparrowhawk. Unfortunately, both airships met disastrous ends in severe weather.[4]

Meanwhile in Europe, new airship construction began in support of long-range commercial passenger transportation with varying results. Germany built and flew the *Graf Zeppelin* around the world while Britain built, flew, and lost the R–101, effectively ending its commercial efforts. The Germans then built an even larger airship, the *Hindenburg*. After a successful season on the North Atlantic run, it went up in flames over Lakehurst, New Jersey, in 1937. That disaster was a turning point. The *Graf Zeppelin* was removed from commercial service. While German airships were successful on the Atlantic crossing, airship disasters and the appearance of fast, long-range American flying boats such as the Boeing Clipper meant their days were numbered.

Meanwhile, the Lighter than Air Bureau of the Navy Department was planning a true flying aircraft carrier. Dubbed the ZRCV, this nine million cubic foot ship was designed to carry nine Douglas-Northrop BT–I dive bombers. But it was not to be. President Franklin Roosevelt limited the size of new airships. This decision proved to be the death of lighter than air carriers. While the weight of any aircraft a ship might carry increased with improved technology, the lifting weight of helium remained constant. Because of restrictions in size the flying aircraft carrier never became anything more than a blueprint.



C–47 snatching glider at Asansol, India.

U.S. Air Force History Office

Glider landing in Lubbock, Texas.

U.S. Air Force History Office

Germany built one last ship, the *Graf Zeppelin II*, a sister to the *Hindenburg*. Its designers hoped America would relent and allow the export of helium. When relations with the United States worsened, any possibility of reviving commercial airships vanished. In the summer of 1939, however, Germany discovered another mission for the technology, electronic warfare. Flying along the North Sea coast of England, the airship searched for emissions from British radar home chain stations. But its receivers were tuned to the wrong frequency and found nothing. The project was abandoned.

Despite the possibility of varied missions, the leading characteristics of airships—heavy lift and range—were not recognized early enough. They proved most successful at strategic airlift and long-range passenger transport. By the time they came into their own with these missions, airplanes were emerging as superior.

## The Glider

Although gliders preceded airplanes in development, their obvious disadvantages left them behind as airplane technology advanced. But when the Versailles Treaty prohibited Germany from having an air force after World War I, nonpowered flight emerged as a substitute. Looking forward to a day when the ban would be lifted, Germany fostered nominally civilian gliding clubs which developed a cadre of glider pilots who could make the transition to powered aircraft.

By World War II Germany, with a pool of pilots skilled in nonpowered flight, integrated gliders into its airborne forces, but military doctrine generally restricted gliders to commando raids. A notable exception was the invasion of Crete in 1941, when heavy losses suffered by German airborne formations did nothing to encourage more extensive use of gliders.[5]

On the other hand, the dramatic success of glider troops in operations such as the seizure of Eban Emael in Belgium caught the attention of the Allies. British plans for glider use resembled those of Germany while the Americans focused on mass airborne troop transport and resupply. The U.S. Army employed gliders for the invasion of Sicily, Normandy, and southern France. In addition, they were used in Operation Market Garden, the strike into Holland in September 1944, in Burma in 1944, and Operation Varsity, and the attack over the Rhine in March 1945.

Although American glider operations were generally successful, there were problems. The lack of preexisting glider forces resulted in a rush to produce gliders and train pilots. Predictably, this compromised the quality of both. Moreover,

the craft faced major tactical limitations. Gliders under tow were highly vulnerable to interceptors and ground fire. Adverse weather interfered with flight operations. Because they were rarely reusable, gliders were an expensive expendable item. Also there was the problem of what to do with the pilots on reaching the target area. Should they be used as infantry or returned to base? The British trained their pilots in infantry tactics and expected them to fight on the ground. Americans never satisfactorily resolved the question.

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U.S. gliders were transferred to the Air Force when it became a separate service following World War II. There was interest in developing larger and more modern gliders, but the Air Force made little headway. By 1950 air assault aircraft had replaced gliders. C–123s and other aircraft made gliders obsolete for delivering troops and supplies, as helicopters did for commando raids. Gliders disappeared from the inventory after a life span of only a decade.

## Inflight Refueling

The first experiments with refueling in the air took place in the United States, Great Britain, and France in the early 1920s. It was a period when the emphasis was on setting aviation records rather than using innovations to solve practical problems. For example, on New Year's Day 1929 a Ford C–2A trimotor named *Question Mark* began a dramatic demonstration of inflight refueling on a racetrack course between Van Nuys and San Diego. Two Douglas C–I single-engine biplanes acted as tankers and refueled the trimotor through hoses 43 times. *Question Mark* finally landed on January 7 after over 150 hours in the air.[6] This experiment encouraged others to break the record for inflight refueling. In 1935 it rose to 27 days, a record that has never been broken.

Such records overshadowed the role of inflight refueling as a range extender. Experiments continued, but unpredictable weather conditions and other factors hindered success. In the 1930s technology made inflight refueling less relevant for the range of aircraft. The transition from wood and fabric biplanes to all-metal monoplanes led to advances in speed and range. Manufacturers in America began building flying boats that carried passengers nonstop across the Atlantic. Inflight refueling was more or less forgotten in the United States.

British interest in aerial refueling persisted. Designers had difficulty developing a flying boat that could cross the Atlantic without refueling. Alan Cobham established Flight Refueling Limited and introduced a new refueling system. He conducted experiments with British Imperial Airways and was planning a joint venture with Air France when war intervened.

World War II offered opportunities to exploit inflight refueling, but none came to fruition. The most regrettable failing was not closing the mid-Atlantic gap in the battle against German submarines. Cobham approached the Air Ministry about using inflight refueling for the Short S–25 Sunderland maritime reconnaissance bomber. Increasing the reach of this four-engine flying boat would have covered the gap with existing aircraft and tipped the scales in favor of the convoys. The government declined to act and the gap was not closed until mid-1943 by unrefueled B–24 Liberators.

After the war Britain returned to efforts to perfect inflight refueling for commercial aviation. Some technical obstacles were gradually overcome with a cumbersome albeit effective looped hose system, but new American airliners such as the Lockheed Constellation could cross the Atlantic without refueling. Aerial replenishment seemed headed for oblivion.

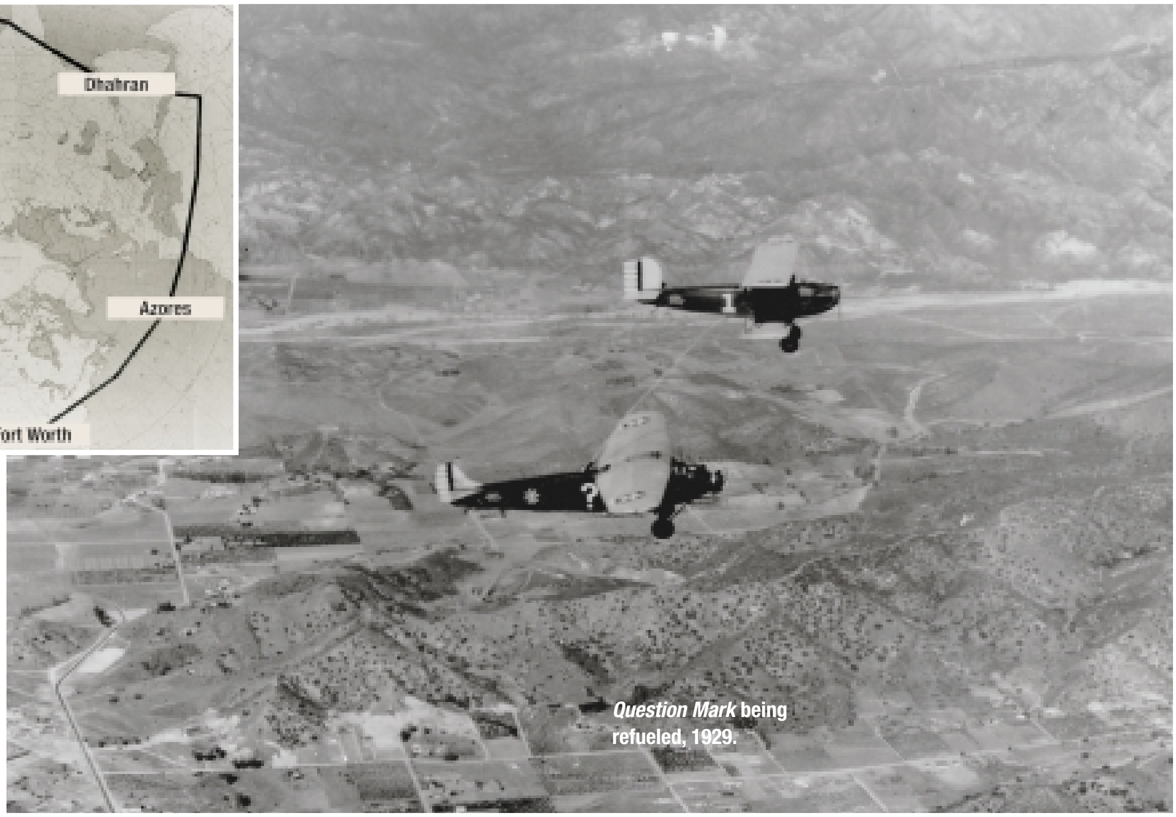
In the late 1940s, however, inflight refueling got a second chance. As the Cold War began the Air Force lacked bombers that could hit targets deep inside Soviet territory. Its primary bomber was the B–29 Superfortress. An upgraded version, the B–50, was also inadequate for the mission. The only bomber able to penetrate far into the Soviet Union was the B–36. Although its range was an advantage, this six-engined behemoth was slow and vulnerable. Design work on what would become the B–52 was begun, but aeronautical engineers quickly ran into a problem. To get the necessary range they had to increase the fuel capacity; but that made the aircraft bigger and further increased fuel requirements.

A committee of the Air Force Aircraft and Weapons Board developed a list of needs which included reduced range and inflight refueling. A team headed by Jimmy Doolittle went to England to meet with Alan Cobham. They returned with equipment and contracts, and work soon started on converting B–29s into KB–29 tankers. In February 1949, with KB–29s providing four inflight fuelings, a B–50 named *Lucky Lady II* took off from Carswell Air Force Base in Texas and flew around the world nonstop in 94 hours.

The Air Force soon replaced the cumbersome Cobham looped hose system with a Boeing telescoping boom. KC–97s supplanted KB–29s. In turn the KC–135 Stratotanker, a Boeing 707 derivative specifically designed for operating with B–52s, replaced the KC–97. In the meantime, the British developed the probe and drogue system.


U.S. Air Force

**Round-the-world route of *Lucky Lady*.**



***Question Mark* being refueled, 1929.**

U.S. Air Force History Office

Both the boom and the probe and drogue systems had advantages. The boom has been most popular with the Air Force, but the probe and drogue system has often been adopted by the other services as well as foreign air forces.

Inflight refueling eventually spread beyond strategic bombers. The conflicts in Korea and Vietnam demonstrated the value in air fueling for tactical aircraft. During the Vietnam War tankers not only extended tactical strike aircraft range but often saved damaged aircraft returning to base by replenishing fuel lost through leaking tanks.

What was once a stunt and then a niche technology blossomed into a widespread innovation. Today, inflight refueling is integral to military aviation in the United States.

## Myth of Technology Trees

Enthusiasts of computer games such as Civilization are familiar with the technology tree. Players seek revolutionary technologies to acquire new types of military units, city improvements, and other advantages. However, they must follow a tree that identifies mandatory technological prerequisites. For example, a player seeking *gunpowder* must first acquire *invention* and *iron working*. *Invention*, in turn, depends on *engineering* and *literacy*. Each advance is a consequence of one technology and prerequisite for another. Such linear advances constitute a technology tree.

But technology trees are myths. New developments do not follow predetermined paths. The evolutionary steps taken to obtain a technology do not constitute the only approach to it. Nor is the most prevalent form of development necessarily even the most efficient.

Technological choices are often made by accident or for nontechnological reasons. Today most people use videos in a VHS format rather than Beta, which is generally regarded as superior. Business decisions and economic costs gave VHS an early lead that Beta could not overcome as the investment in VHS tapes and machines increased. Moreover, typewriters and computers utilize the *qwerty* keyboard, named after the line of six letters on the upper left hand portion of the board. This arrangement was designed to slow typing to prevent keys from jamming. The more efficient Dvorak keyboard has been around since the 1930s, but familiarity with the qwerty keyboard has created inertia against change.[7]

Likewise the automobile, powered by the internal combustion engine, is the dominant form of personal transportation. But in 1914 steam and electricity were serious contenders. Engineers still claim steam engines offer the most efficient propulsion for cars. Steam lost because accidents,

engineering choices, market decisions, and economic factors combined to give internal combustion market domination by 1930. The size of the automobile industry and its supporting infrastructure became a barrier to change. Building a steam powered car was not enough. One needed networks of dealers, parts suppliers, and service stations. Once again, existing investments as sunk costs generated inertia to change. Robert Pool calls these type of barriers technological lock-in.[8]

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What then are the implications of technological determinism? Clearly some prerequisites are more important than others. But a given technology need not follow the same development path as it did in our civilization, nor must it manifest itself in its present form.

### False-Failed Innovations

Many military innovations are technology based, though not all. To achieve an innovation, an enabling technology must be linked to doctrine and organizations able to wield new capabilities.

The tank and aircraft carrier were successful innovations which were based on technology. Efforts such as the airship never achieved dominance. Still others such as gliders succeeded only briefly. Then there were innovations such as inflight refueling that were discarded but reappeared when needs and circumstances changed. They are false-failed innovations.

To succeed technology must meet a need that involves choices and tradeoffs. Needs shape development. Provided needs are met, technology can be shaped in various ways, even irrational ones. As needs change over time, so do the characteristics of a given technology.

Air refueling is a classic illustration of how variables play on technological progress. There was little practical use for refueling in flight during the 1920s or 1930s and the concept languished, though British aviation circles kept the basic notion of the technique alive. Thus when an urgent need arose in the Air Force during the 1940s the technology base was ready. Capabilities remained about the same during these decades, but it changed rapidly after 1948. Organizations and doctrine were created that turned the technology into an innovation. Air Force commands grouped tanker aircraft into tanker squadrons and wings within existing organizations. Doctrine evolved as what began as a range extender for bombers spread to tactical aircraft, transports, and helicopters.

The myth of the technology tree only looks toward a narrow set of possibilities, building on what is in use today rather than considering alternative paths such as suitable developments of the past that were prematurely committed to oblivion. All too frequently discarded technologies are ignored. Yet technologies that are inappropriate in one age have been resurrected through adaptive methods and organizations to fill essential requirements at a later time. This process of innovation demolishes the notion that the predictive linear growth of innovations along a single technological course is the only road to the future.

To maximize the capacity to exploit new capabilities, innovators must recognize that past technology is malleable and may evolve into something quite different. And there must be a clear grasp of future requirements. Needs drive how technology is shaped and used. Only by analyzing requirements thoroughly and defining them objectively, unconstrained by narrow thinking about how traditionally military capabilities have been used, can a failed technology become a false-failed innovation. Look first to needs. Revising organization and doctrine must follow, then identifying available technology. Achieving innovations, false-failed or otherwise, frequently requires vision but always calls for hard thinking that transcends a didactic, linear conception of how technology becomes capability. JFQ

NOTES

[1] John H. Morrow, Jr., *The Great War in the Air: Military Aviation from 1909 to 1921* (Washington: Smithsonian Institution Press, 1993), p. 68.

[2] Douglas H. Robinson, *The Zeppelin in Combat: A History of the German Naval Airship Division, 1912–1918* (Seattle: University of Washington Press, 1980), p. 67.

[3] Robinson, *The Zeppelin*, pp. 284–93, and Peter W. Brooks, *Zeppelin: Rigid Airships 1893–1940* (Washington: Smithsonian Institution Press, 1992), pp. 103–04.

[4] Brooks, *Rigid Airships*, p. 172, and Richard K. Smith, *The Airships Akron and Macon: Flying Aircraft Carriers of the United States Navy* (Washington: U.S. Naval Institute Press, 1965), pp. 70–71.

[5] Jonathan C. Noetzel, *To War on Tubing and Canvas* (Maxwell Air Force Base, Ala.: Air University Press, 1993), p. 3.

[6] Richard K. Smith, *Seventy-Five Years of Inflight Refueling: Highlights, 1923–1998* (Washington: Air Force History and Museums Program, 1998), pp. 3–7.

[7] Jared Diamond, *Guns, Germs, and Steel: The Fates of Human Societies* (New York: W.W. Norton, 1997), pp. 239–64.

[8] Robert Pool, *Beyond Engineering: How Society Shapes Technology* (New York: Oxford University Press, 1997), pp. 152–61.